Adventures with ACT-R 5.0

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The Argus Prime Model is an engineering model of a complex dynamic highly interactive task. The model is written in ACT-R 5.0 and takes full advantage of the integration of cognition, perception and motor actions that ACT-R 5,0 provides. In fact, this model is intended to be a “proof of concept” for applying ACT-R 5.0 to complex Human Computer Interactive (HCI) environments. The model is not only capable of responding to different interface conditions but also captures the mix of interactive strategies found in humans doing the task. We first review the Argus Prime Task including both the primary classification task and the secondary tracking task. An overview of the model structure is presented including some execution data. The mechanism by which the model is configured to capture the mix of user strategies is outlined. The overall operation of the model is then described at the unit task level. We conclude with the data that shows no significant differences between model and human performance.

Argus was developed with Air Force funding to study cognitive workload. It can run either as a single classification task or with a secondary tracking task. It entails dynamic decision-making in the context of a radar-tracking task that requires the interaction of human cognitive, perceptual, and motor operations. As subjects use Argus, we collect and time stamp every mouse click, every system response, every mouse movement, and interleave these records with point-of-gaze data collected 60 times per second.

The Classification Task is the primary task for Argus. This task entails classifying a varying number of targets on a radar screen. The targets can change direction, speed, or altitude at any time. Over a 15-min scenario, the participant's task is to determine the threat value of each target each time it enters one of four, 50-mile sectors (sectors are indicated by concentric circles on the radar side of the Argus screen). Subjects are taught a classification algorithm that requires them to estimate a value on each of a number of attributes, weigh each attribute, sum the value by weight combinations, and translate the sum to a 7-pt scale.

The Tracking Task is a highly perceptual motor task added to the primary task to increase workload. On the right side of the screen a plane icon is constantly changing its position. The subject must keep a circular cursor positioned over the plane. The color of the circular cursor provides feedback to the subject as to how well the plane is being tracked.

The model is based on a task analysis that decomposes the classification task into three unit tasks: target selection, classification, and feedback processing. When the tracking task is added, it is executed between transitions from one unit task to the next.

To account for between subject variability, “model subjects” are created using a dialog box. This allows the experimenter to set a mix of strategies to be executed by the model under the various interface conditions. The sources of between subject variability are due to differences in interface interaction strategies, visual search strategies, and cognitive operations.

Two experiments have been conducted. The first experiment (AP4) was conducted in a single task environment (classification task). The second experiment (AP5) was conducted in a dual task environment (classification + tracking). Twenty-four human subjects were run in AP4 and twenty-four different subjects were run in AP5. To compare model performance with human performance, twenty-four model subjects were created for AP4. These same model subjects were run in AP5 with the addition of one parameter for tracking.

The model consists of 243 productions, with 33 of them performing multiple actions. In a 12-minute period, about 7200 productions are fired and about 1700 episodic memory elements are created.

The model implements multiple target selection strategies. A particular strategy is chosen for each execution of the target selection unit task based on the current state of the environment. Each strategy is implemented by low-level productions that perform pre-attentive feature searches. The model makes extensive use of the attentional marking feature of the ACT-R 5.0 architecture.

We compare model performance with human performance on a number of output measures for both AP4 and AP5 plus performance on the tracking task in AP5. The model does not differ significantly from human performance on the measures we present.

We argue that this is the most complex ACT-R 5.0 model produced to date. The model subjects created in AP4 were successful in predicting performance in the AP5 experiment. These results serve to strengthen the claim that our engineering approach in conjunction with the ACT-R 5.0 architecture is superbly suited Human Computer Interactive applications.